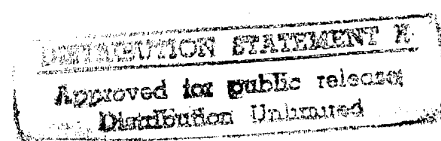


DEVELOPMENT OF A LITHOGRAPHIC TECHNIQUE FOR  
SUPERCONDUCTING YBCO FILMS

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## INTRODUCTION

The research is devoted to developing a new patterning technique for superconducting YBCO films. The technique is based on the fact that YBCO films exhibit superconducting properties only if deposited on substrates that allow epitaxial growth of YBCO films whereas deposition on other types of substrates results in insulating YBCO films regardless deposition conditions. Such a dependence of YBCO superconductivity on epitaxial nature of its growth can be used for obtaining patterned superconducting films without subjecting YBCO films themselves to any chemical, thermal or mechanical treatment. Instead, a patterning procedure can be applied to substrate, with the aim to produce substrate surface composed of two different materials, with only one of them to allow growth of superconducting YBCO film. If this component of the composite substrate has been patterned to a required configuration, the obtained superconducting YBCO film will be also patterned.

Two materials that have been chosen for obtaining a composite patterned substrate in this study are orientated single crystal strontium titanate  $\text{SrTiO}_3$  and amorphous  $\text{SiO}_2$  film. The research will consist of three main stages:

- deposition of  $\text{SiO}_2$  films on  $\text{SrTiO}_3$  substrates;
- patterning  $\text{SiO}_2$  films;
- deposition of YBCO on prepared composite substrates.

The work performed during initial three months of the research can be summarized as follows:

- $\text{SrTiO}_3$  plates with surface orientation (100) and polished from one side to be used for substrates have been ordered;
- lithographic masks intended for evaluation of patterning resolution have been designed;

- first experiments on depositing amorphous  $\text{SiO}_2$  layers have been performed.

### Deposition of Intermediate $\text{SiO}_2$ Layers

There are several deposition techniques that produce thin  $\text{SiO}_2$  films. The obtained films can differ in their density, adhesion to the substrate and the content of silicon and silicon mono-oxide. We have decided to try three different deposition techniques:

1. Thermal vapor deposition using electron beam heating and fused quartz as a target.
2. Argon sputtering in oxygen atmosphere using silicon cathode.
3. Plasma enhanced CVD from a gas mixture of silane ( $\text{SiH}_4$ ) and  $\text{N}_2\text{O}$ .

In all preliminary experiments deposition of  $\text{SiO}_2$  was performed on silicon wafers. Film composition was verified by measuring refraction index of the deposited layers ( $\text{SiO}_2$  has refraction index close to 1.45 whereas  $\text{SiO}$  and silicon give much higher values). Thickness of deposited layers was measured by using  $\alpha$ -step profilometer.

Because in the course of the research we wish to evaluate the effect of thickness of intermediate  $\text{SiO}_2$  layer on the patterning resolution and the quality of thin superconducting YBCO bridges it was decided to perform patterning experiments using  $\text{SiO}_2$  layers of three different thicknesses, namely, 500, 1000 and 1500 Å.

## Mask Design

Lithographic masks that have been developed for this study have a special design. The aim of the design is to provide a possibility for an easy determination of the minimum width of exposed  $\text{SrTiO}_3$  areas on the patterned substrate surface that still allows to obtain superconducting bridges in these areas after YBCO deposition.

The developed design is shown in Fig. 1; the pattern configuration is common to two masks but they differ in the size of certain elements in the mask design. Both masks are intended for the use with a positive photoresist. Shaded areas in Fig. 1 correspond to  $\text{SiO}_2$  layer preserved after substrate patterning and, therefore, to insulating areas in YBCO film deposited on the patterned substrate. Unshaded areas, respectively, correspond to  $\text{SrTiO}_3$  surface exposed during substrate patterning and, therefore, to superconducting areas in YBCO film deposited on the patterned substrate.

The masks have been designed with the aim to allow an easy evaluation of the most important characteristics of the patterning technique, namely, the lowest width of superconducting YBCO bridges that can be achieved, by simply measuring superconductivity of deposited YBCO films by four probe method. For example, if all narrow YBCO bridges in the unshaded area (a,c,e in Fig. 1) will be superconducting it can be confirmed by measuring YBCO film conductivity with four contacts at locations 1 to 4 in Fig. 1. In the case that the narrowest bridges in the pattern ("a") are insulating the quality of other bridges can be evaluated by placing contact at location 5 instead of 1. If bridges "e" are also insulating the quality of the widest bridges "c" can be then checked by placing contacts in locations 2,3,5 and 6. Thus, the quality of obtained patterned YBCO films can be easily evaluated by using six preliminary deposited contact areas.

